Mapping Active Faults in the Houston Area Using LIDAR

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EXTENDED ABSTRACT

The coastal region of the northwestern Gulf of Mexico remains tectonically active. In the Houston area alone there are over 300 active surface faults. Figure 1 shows a map of the Houston area which includes major faults and salt domes. The faults in northwest Houston are regional faults while the faults in southeast Houston are associated with salt domes (Verbeek and Clanton, 1978). The faults cause damage to man-made structures such as roads, pipelines and buildings. We used LIDAR DEM (LIght Detection And Ranging Digital Elevation Model) images from the 2002 Tropical Storm Allison Recovery Project (TSARP) to examine known faults and to search for others that may have been overlooked in previous studies. Our work focused on the faults in northwest Houston.

Figure 2 is a LIDAR DEM for a portion of northwest Houston. In this location the elevation difference on the Longpoint Fault is distinct. We used hill-shading as the primary visualization method for locating the faults. Figure 3 illustrates the elevation aspects of the interpretation process. The scarp is evident in the photo. Figure 4 illustrates the value of using the hill-shaded DEMs for interpretation. The fault is clear in Figure 4A, while not detectable in the aerial photo in Figure 4B. Later we examined the faults in the field (*e.g.*, Fig. 3C). A field visit helps explain the kink of the fault in Figure 5A. The east-west portion of the fault runs along the property line indicating the lot to the south was excavated to a constant elevation. Figure 5B is a field photo of the fault ramp at this location. At some locations fault deformation and associated damage were evident, while in other locations field expression of the fault was subtle and the presence of a fault was difficult to confirm. In some areas we used refined grids, using both raw data and supplied DEM, to define known faults better and to identify previously unknown faults. Figure 6A shows a refined DEM grid which was hill-shaded and interpreted. The fault splits into several branches in this area. Figure 6B shows two of the fault ramps.

Study of these faults may also help in understanding the underlying tectonics. Figure 7 shows our model for the relationship between faults and salt (based upon Jackson *et al.*, 2003). The regional faults are tied to the withdrawal of salt. Further work is needed to confirm this model.

Proper documentation of active surface faults is important so that developers can avoid building in the zone of disturbed ground along them. In some cases developers and builders have taken steps to avoid construction on fault traces, often by leaving the land as an open greenbelt or as a storm water detention pond. In other cases structures have been built unknowingly within fault zones.

REFERENCES CITED

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Verbeek, E. R., and U. S. Clanton, 1978, Map showing faults in the southeastern Houston metropolitan area, Texas: U.S. Geological Survey, Open File Report 78-797, 21 p., and folded map.

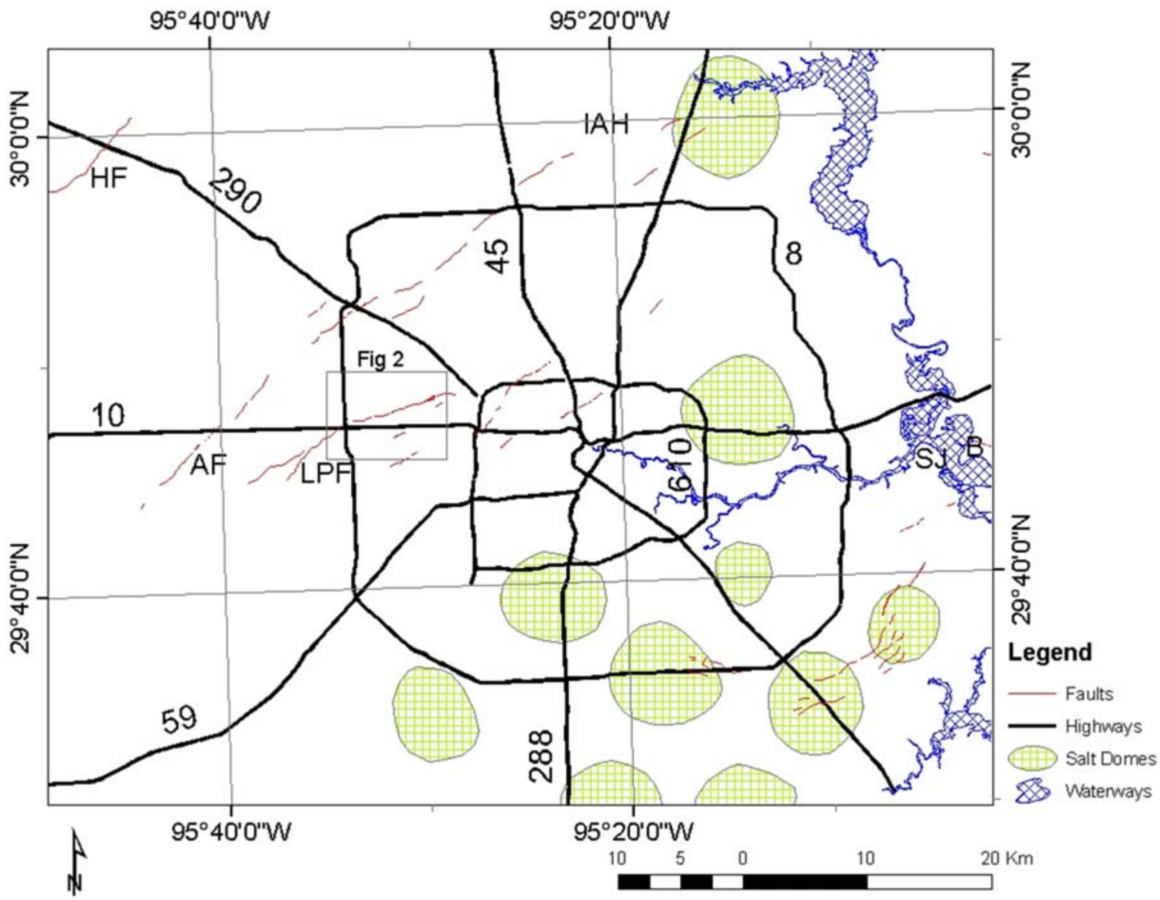


Figure 1. Houston area map showing active surface faults interpreted using LIDAR and the locations of salt domes. Tics are placed on the downthrown side for the faults in northwest Houston. Note that the faults in northwest Houston have a NE-SW regional trend but faults in southeast Houston tend to radiate from the salt domes. Salt dome locations are derived from O'Neil and van Siclen (1984). Major highways and waterways provide context. Labels for some key faults: HF – Hockley Fault; AF – Addicks Fault; and LPF – Long Point Fault. IAH – Houston Intercontinental Airport (now George Bush Intercontinental Airport); SJ – San Jacinto Monument; and B – Brownwood subdivision. The location of Figure 2 is also shown.

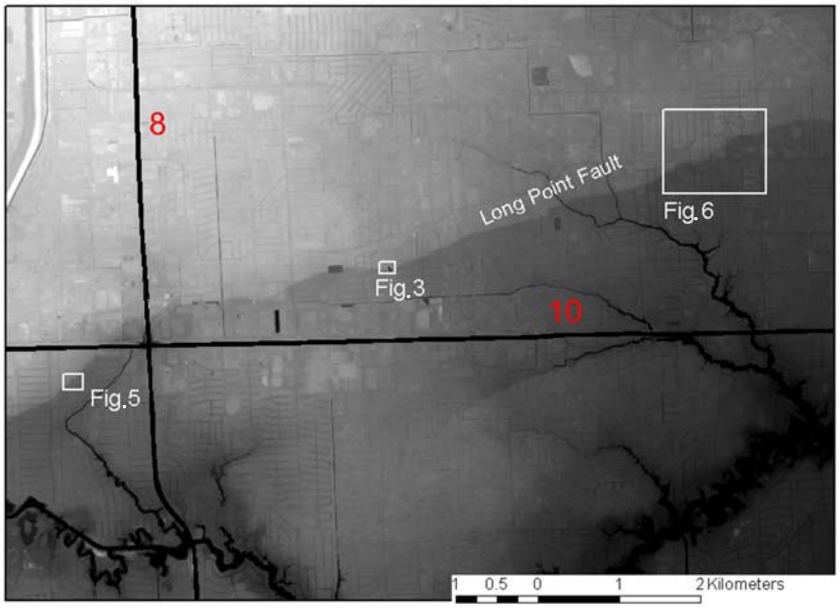


Figure 2. LIDAR DEM image. The elevation break along the Long Point Fault is clearly identified. Also shown are the locations for Figures 3, 5, and 6. North is to top of image.

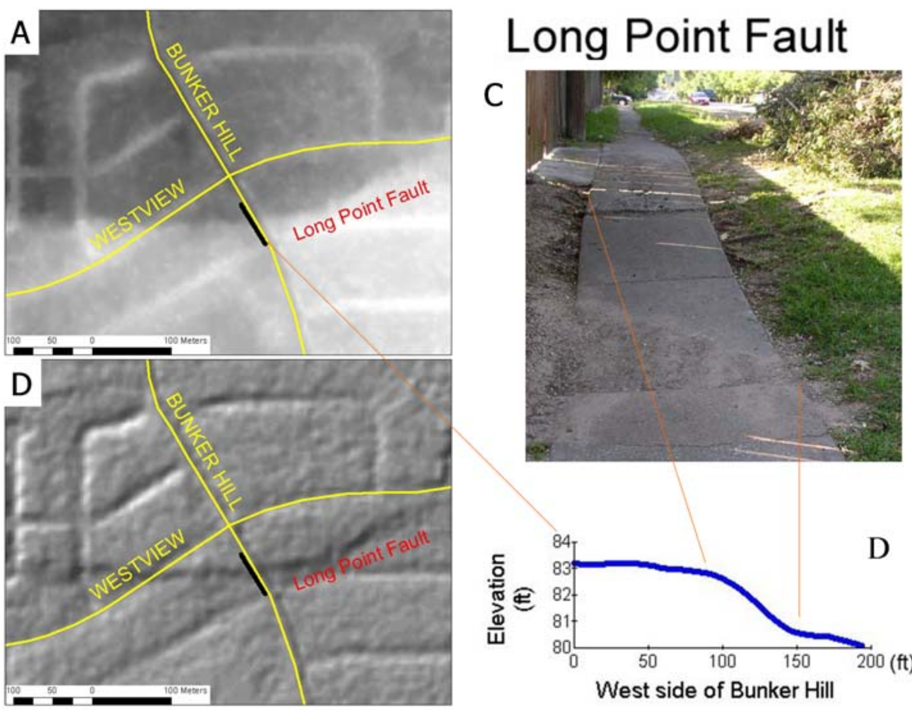
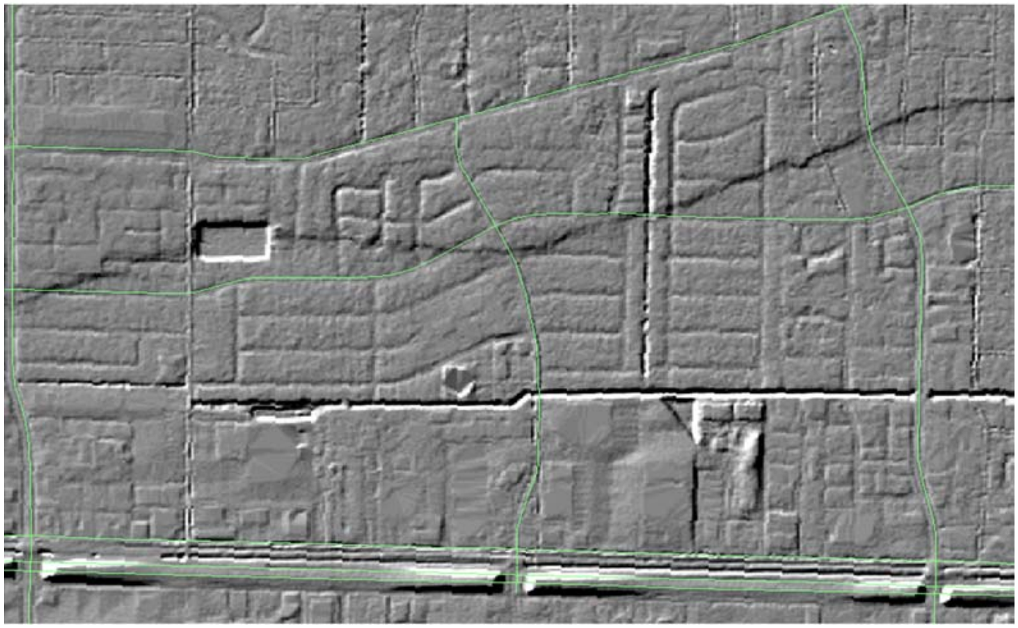


Figure 3. Long Point Fault at Bunker Hill: (A) LIDAR data. (B) Hill-shade image computed from LIDAR DEM. 'Sun' elevation is 45 degrees and azimuth is 315 degrees. Lighter shades correspond to brighter illumination. (C) Photo looking updip along west side of Bunker Hill. Lines show where the top and bottom of the ramp match the profile in D. Note tilted sidewalk slabs along scarp face. (D) Northwest-southeast profile along Bunker Hill. Arrow shows location on part A. Extent of profile is shown by black line in parts A and B.

A) LIDAR shows Longpoint Fault



B) Fault is Not Visible on Orthophoto

Figure 4. A) 15 ft by 15 ft grid cells on hill-shade map. Hill-shading highlights maximum spatial rate of change of surface. B) 1 ft by 1 ft grid cell orthophoto; zoomed in so that individual trees are visible (January 2002 orthophoto).

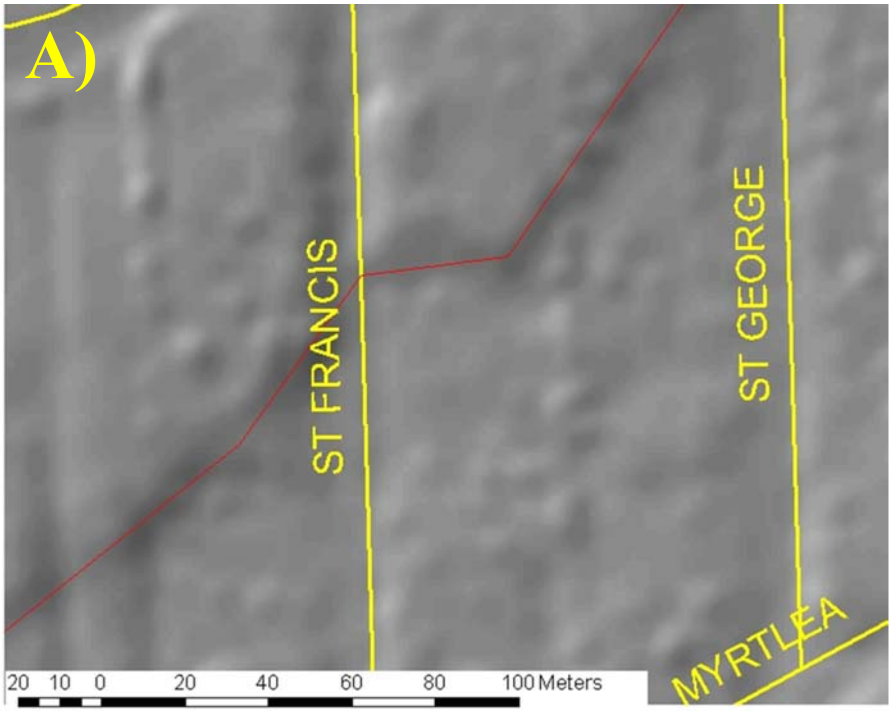


Figure 5. A) Hill-shade image showing Long Point Fault where it crosses St. Francis Street. East-west segment of trace on east side of St. Francis runs along property line between 2 houses. The kink in the trace thus appears to be man-made. With ongoing fault movement the house on the south side of the scarp is at risk. North is to top of image. B) Looking east at ramp along property line. This corresponds to the kink in the fault in A.

Figure 6. A) LIDAR hill-shade image of Long Point Fault where it crosses Long Point. Here the scarp bifurcates into several branches. B) Two separate scarps can be seen in the distance (highlighted by the red dashed lines). A third scarp has been interpreted further north but is subtle and gentle.

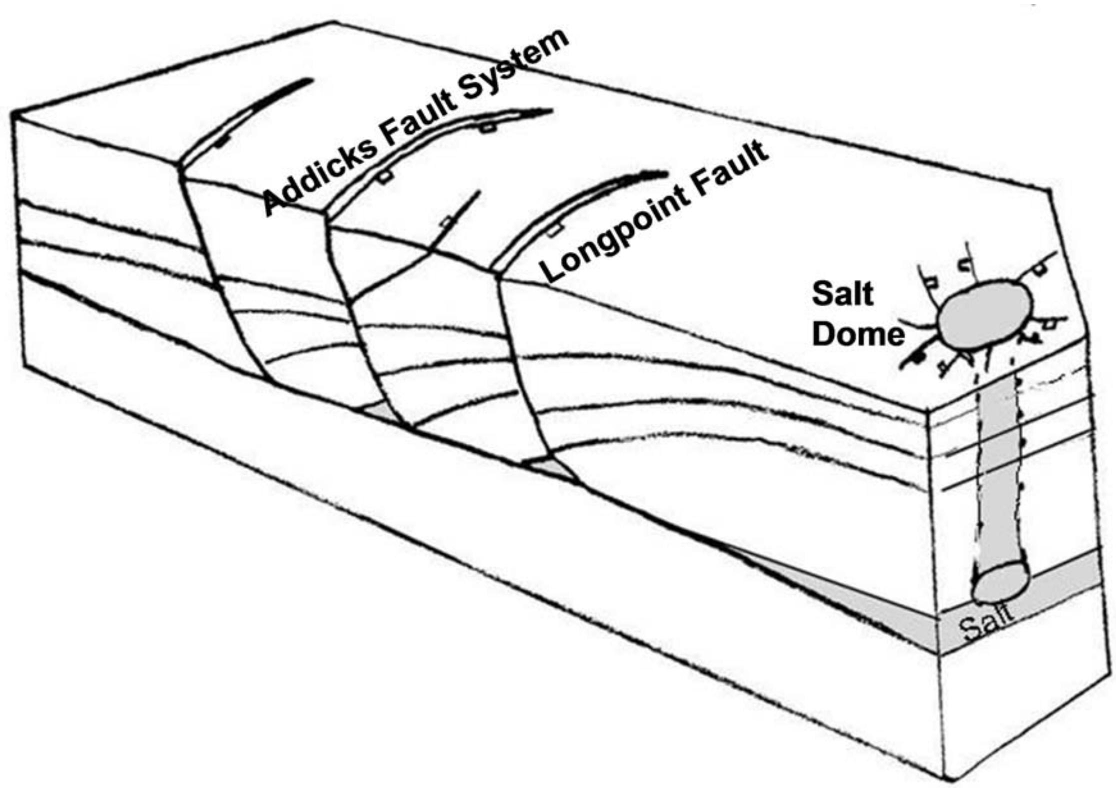


Figure 7. Proposed model for Houston area faults showing relationship to salt in subsurface. The active surface faults are shown as continuing downward into growth faults. The growth faults sole out in structures resulting from the withdrawal of salt. Some of the salt rises in salt domes downdip of the faults.